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How Do Profoundly Deaf Children Learn to Read?*

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Abstract. Reading requires two related, but separable, capabilities: (1) familiarity with a language, and (2) understanding the mapping between that language and the printed word (Chamberlain & Mayberry, 2000; Hoover & Gough, 1990). Children who are profoundly deaf are disadvantaged on both counts. Not surprisingly, then, reading is difficult for profoundly deaf children. But some deaf children do manage to read fluently. How? Are they simply the smartest of the crop, or do they have some strategy, or circumstance, that facilitates linking the written code with language? A priori one might guess that knowing American Sign Language (ASL) would interfere with learning to read English simply because ASL does not map in any systematic way onto English. However, recent research has suggested that individuals with good signing skills are not worse, and may even be better, readers than individuals with poor signing skills (Chamberlain & Mayberry, 2000). Thus, knowing a language (even if it is not the language captured in print) appears to facilitate learning to read. Nonetheless, skill in signing does not guarantee skill in reading—reading must be taught. The next frontier for reading research in deaf education is to understand how deaf readers map their knowledge of sign language onto print, and how instruction can best be used to turn signers into readers.

Most profoundly deaf children read poorly. However, a small minority learn to read fluently. Understanding how profoundly deaf children learn, or fail to learn, to read is important for at least two reasons. First, the more we understand the process by which deaf children read, the more we can do to improve that process in the deaf population. Second, understanding reading in deaf children has the potential to inform us about reading in all populations.

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WHY MIGHT DEAF CHILDREN BE DISADVANTAGED WHEN LEARNING TO READ?

Virtually all children learn to speak effortlessly. Yet not all learn to read and reading is often difficult. Why? To become readers, children must learn the mapping between the spoken language they already know and printed words on a page. For English, as for most languages, that mapping is based on sound. Once children understand the underlying principles of the print-sound mapping—once they "crack the code"—they can call upon their knowledge of their spoken language to facilitate the reading process. Profoundly deaf children are disadvantaged as potential readers on both of these counts—they do not have easy access to the phonological code and many do not know any language well, let alone the language captured in print.

Reduced Access to the Phonological Code

Profoundly deaf children have inadequate access to the auditory basis for print-sound mapping. Roughly one in 1,000 children born in the United States is severely to profoundly deaf (Ruben, 1972). A child with a severe (70 to 89 decibel) hearing loss is unable to hear even shouted conversation and thus cannot learn speech as a normally hearing child would. A child with a profound ($\geq$90 decibel) loss hears only occasional loud sounds and these sounds may be perceived as vibrations rather than sound patterns.

A deaf child's limited hearing abilities can be augmented with hearing aids, and amplification via a hearing aid does increase a child's awareness of sound. However, the extent to which a hearing aid can help the child learn a spoken language depends on many factors, including which speech frequencies the child is able to hear with the hearing aid and the extent to which speech sounds remain distorted despite amplification (Moores, 1982; Seyfried & Kricos, 1989). The cochlear implant is a relatively new device designed to improve upon the hearing aid. Unlike a hearing aid, which is removable, the cochlear implant is surgically placed inside the portion of the inner ear that converts sound to neural signals (the cochlea). The implant receives signals from an external device worn behind the ear and stimulates electrodes in the cochlea; the electrodes stimulate the auditory nerve directly, bypassing the hair cells that implement the first stage of auditory neural processing in intact ears. Cochlear implants appear to improve hearing for adults who become deaf after having a spoken language. However, the data are much less clear for prelingually deaf children who must *learn* spoken language through the device (Owens & Kessler, 1989; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000).

It is hardly surprising, then, that children born with severe to profound hearing losses often do not achieve the kind of proficiency in spoken language that normally hearing children do. Even with intensive oral instruction, deaf children's acquisition of speech is markedly delayed when compared to the acquisition of speech by normally hearing children of hearing parents (Conrad, 1979; Mayberry, In press; Meadow, 1968; Seyfried & Kricos, 1989). The bottom line for profoundly deaf children is that they do not have access to the same auditory base that normally hearing children do.

Reduced Access to the Language Captured in Print

Profoundly deaf children typically have imperfect knowledge of the language that is mapped by the print system they are learning—English, for children learning to read in the United States. Perhaps surprisingly, the language a deaf child typically learns differs for children born to deaf vs. hearing parents.

Deaf Children Born to Deaf Parents

Speech is not the only route to language. Language can be learned through the eye and hand rather than the ear and mouth, that is, children can learn a signed rather than a spoken language. Deaf children born to deaf parents are very likely to be exposed to a natural sign language such as ASL from birth. These children learn ASL as their first language. They learn ASL easily, as easily as hearing children learn English (Lillo-Martin, 1999; Newport & Meier, 1985). Unfortunately for the potential deaf reader, ASL is *not* English.

Sign languages are autonomous languages, not based on the spoken languages of hearing cultures (Bellugi & Studdert-Kennedy, 1980; Emmorey, In press; Klima & Bellugi, 1979; Lane & Grosjean, 1980). The structure of ASL is distinct from the structure of English. Indeed, the structure of ASL is distinct even from the structure of British Sign Language—a fact that dramatically underscores the point that sign languages are not derivative from spoken languages. Indeed, ASL is closer in structure to polysynthetic languages such as Navajo than to English (Newport & Meier, 1985).

The bottom line for many deaf children born to deaf parents is that, although they are native (and fluent) users of a language (sign language), that language is *not* the language they are learning to read.

Deaf Children Born to Hearing Parents

Ninety percent of deaf children in the United States are born to hearing parents, who are not likely to know sign language. As a result, these deaf children will not be exposed to sign language at birth.

Before 1960, the only educational option available to young deaf children in the classroom was oral instruction without sign language. It was not until 1960, when Stokoe published the first linguistic analysis of ASL, that educators began to realize that the manual modality could support language. Although ASL was slowly earning recognition as a "real" language, the prevailing belief among teachers of the deaf was that learning to *sign English* ought to be better for learning to *read English* than learning to sign ASL. As a result, educators, both deaf and hearing, invented a number of different sign systems (Signing Essential English, Seeing Essential English, Signing Exact English, Signed English; Lou, 1988) which, as a group, are referred to as Manually Coded English (MCE).[1] All these systems are synthesized—they borrow signs from ASL and syntactic structure from English. The goal is for children to learn the structure of English, not only through the sound and lip-reading patterns of spoken English, but also through the manual patterns of signed English. To foster the development of speech and spoken English, MCE is signed while simultaneously speaking English.

Although perhaps an excellent idea in principle, MCE systems are difficult to process in practice. Teachers of the deaf find it hard to sign and speak at the same

[1] The most current, although at the moment still rare, movement in deaf education recognizes that knowing one language (ASL) makes it easier to learn another (English). Under this model, the goal of the deaf school is to promote and, when necessary, teach ASL as deaf children's first language, and then teach English (either through print, sign, or sound) as their second—in other words, to foster bilingual deaf education (Singleton, Supalla, Litchfield, & Schley, 1998).

time without distorting one of the two systems (Marmor & Petitto, 1979). Moreover, whereas some aspects of MCE are relatively easy to learn, others are not (Schick & Moeller, 1992). Deaf children frequently distort these difficult-to-learn aspects of MCE systems as they learn them, refashioning the systems so that they more closely resemble natural sign languages such as ASL (Gee & Goodhart, 1985; Goodhart, 1984; Livingston, 1983; Supalla, 1991; Suty & Friel-Patti, 1982).

In addition, deaf children of hearing parents gain access to MCE at variable ages, depending on when their hearing losses are discovered and how long it takes to be enrolled in educational programs. And timing matters—children who are exposed to a sign language for the first time in late childhood or adolescence turn out to be less proficient sign language users than those exposed to sign from birth (Mayberry & Eichen, 1991; Newport, 1991). Moreover, deaf individuals who acquire scant language (in sign or speech) during childhood never catch up in adulthood and do not attain native-like proficiency in any language, be it ASL or English (Mayberry, 1993, In press).

Finally, when deaf children of hearing parents are eventually exposed to MCE, the signers they interact with at home are typically neither fluent nor proficient. The children's hearing parents are themselves in the process of learning MCE and thus are novice signers like their children (Moeller & Luetke-Stahlman, 1990).

Despite these obstacles, however, some deaf children educated via MCE read as well as their normally hearing peers. These children tend to be the ones who receive abundant and early input in MCE at both home and school (Schick & Moeller, 1992).

The bottom line for deaf children born to hearing parents is that the linguistic input they receive is variable—in both quality and timing—and, as a result, their output is variable as well. Deaf children of hearing parents may have mastery of a natural language when it comes time to learn to read, but more likely they will not.

HOW WELL DO DEAF CHILDREN READ?

Only 15 percent of white deaf students who graduate from high school, and only 5 percent of African-American and 6 percent of Hispanic deaf high school graduates, read above the sixth-grade level (Allen, 1994). Indeed, the median reading level of deaf high school graduates is fourth grade (Allen, 1986; Trybus & Karchmer, 1977). This level barely approaches newspaper literacy, and does not actually require the reader to have cracked the print code. Even children who are "hard of hearing," that is, children who have only mild to moderate hearing losses, read at lower median levels than do normally hearing children (Allen & Schoem, 1997). Thus, a majority of deaf children (and deaf adults) are not able to get much meaning from print.

However, some profoundly deaf individuals *do* learn to read, and are as proficient at reading as their normally hearing peers. How do they do it, particularly given the stumbling blocks we have identified? How is it possible to learn to read without a deep understanding of the phonological code upon which the print system is based?

The Importance (or Nonimportance) of Understanding the Phonological Code

Surprisingly, it turns out that the best profoundly deaf readers are not necessarily the children who have received the most intensive oral training (Hansen & Fowler, 1987, p. 206; Waters & Doehring, 1990, p. 351). We might have guessed that oral training would promote understanding of the phonological code, which, in turn, would lead to good reading. But there's no good evidence to support this guess. In fact, the findings are, at best, contradictory. For example, Miller (1997) found that deaf sixth graders educated via speech showed levels of phonemic awareness that were no better than those attained by children educated via sign language.

Moreover, unlike hearing readers, orally trained deaf children do not always use phonological information in reading tasks. Waters and Doehring (1990) found that a group of orally trained, school-aged deaf children did not use phonological information on word-recognition tasks. Nemeth (1992) found that a group of orally trained deaf high school students did not use phonological information on a pseudo-homophone task despite the fact that they were good readers. Confounding the issue further, Hanson and Fowler (1987) found that college-aged deaf students who knew and used sign language (and not speech) *did* use phonological information on word-rhyming tasks. It is clear that profound deafness does not preclude the development of phonological processes. However, it is very unclear what conditions lead to the development and deployment of these processes in profoundly deaf children.

In addition, once having acquired phonological skills, deaf children may find that these skills are not as useful as they are for hearing children. For example, phonological decoding helps hearing children at the early stages of reading "sound out" words that they recognize orally but do not yet recognize in print. However, decoding printed words phonologically is of little value if the profoundly deaf child doesn't know the word in the first place (Lederberg, Prezbindowski, & Spencer, 2000; Waters & Doehring, 1990). Thus, even when profoundly deaf children do have knowledge of the phonological patterns that underlie orthographic patterns, this knowledge may not serve the same functions during reading that it does for hearing readers (Chamberlain & Mayberry, 2000).

Undermining the importance of the phonological code even further, profoundly deaf children can be

good readers and still not rely on phonological encoding when they read. Treiman and Hirsh-Pasek (1983) studied deaf and hearing readers who had achieved seventh- and eighth-grade reading levels. They gave these readers sentences that contained words with several initial sounds in common and thus were phonologically confusable (e.g., "she chose three shows to see at the theater"). They then compared performance on these potentially confusable sentences with other control sentences that had approximately the same meaning but no possible phonological confusions (e.g., "she picked two movies to see with her friend"). The readers were asked to judge whether each sentence was grammatically correct. If the readers were using phonological encoding when processing the sentence, they ought to make more errors on the sentences with confusable sounds than on the control sentences. As expected, the hearing readers did. However, the deaf readers did not.

The deaf readers did not appear to be relying on phonological encoding. What then were they using to encode the sentences? In a second study, Treiman & Hirsh-Pasek (1983) gave the readers sentences containing words that were confusable only when translated into ASL. For example, the sentence "I ate the apples at home yesterday" contains four signs that are all produced with a fist handshape placed somewhere around the mouth and cheek area (see Figure 1, taken from Treiman & Hirsh-Pasek, 1983). If the deaf readers were translating the printed sentence into ASL, they might find sentences of this sort difficult to process relative to control sentences and, indeed, they did. In contrast, hearing readers should have no particular difficulty with these sentences as they are not confusable in English and, as predicted, they did not.

Thus, the hearing readers had difficulty with sentences whose words were phonologically confusing (with sounds in common). However, the deaf readers had difficulty with sentences whose words were confusing only when translated into sign (with place of articulation and handshape in common). These findings suggest that deaf children read by using a code that is not based on sound.

Yet some deaf readers, often very good readers, do seem to know the sound code of English. The question, whose answer awaits future research, is whether phonological awareness precedes or follows excellence in reading in profoundly deaf individuals. That is, do profoundly deaf individuals become excellent readers because they know something about the sound system of English? Or did they learn something about the sound system of English after having become excellent readers of English orthography? The only way to answer this question is to conduct longitudinal studies of profoundly deaf children as they become proficient readers.

The Importance (or Nonimportance) of Understanding the Language that is Mapped by the Print System

We have seen that children can learn to read without a firm grounding in the phonological system. Can children learn to read English without a firm grounding in English? Interestingly, deaf children born to deaf parents tend to be better readers than deaf children born to hearing parents (see below). But ASL is their native language, not English. How can deaf children of deaf parents be better readers than deaf children of hearing parents?

There are several possible reasons. Deaf children of deaf parents are more likely to have their hearing losses identified early in life and thus are more likely to be placed earlier into appropriate educational environments. In contrast, many hearing parents are surprised to find that their children are deaf and require some period of adjustment to the fact that the children will have difficulty learning English. It is not surprising that deaf parents find it easier to accept and be comfortable with deafness in their children than hearing parents. Deaf parents are therefore often better able to provide social and emotional support within the family.

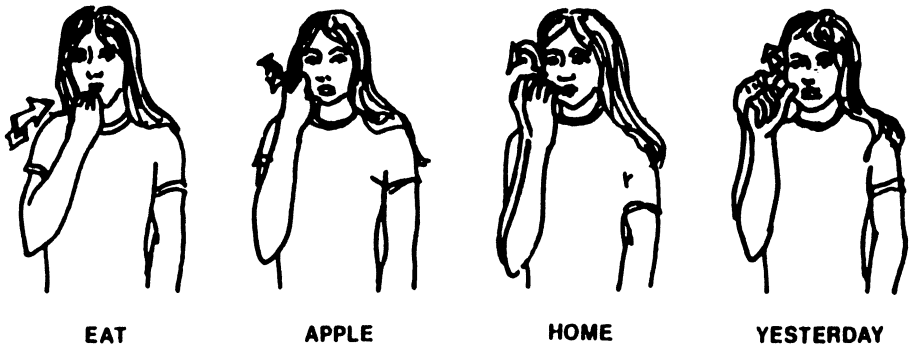

FIGURE 1 ASL signs for "eat," "apple," "home," and "yesterday." When reading the English sentence "I ate the apples at home yesterday," deaf readers translate the sentence into ASL and thus find the sentence relatively difficult to process because the signs in the translation are so similar in form (from Figure 3 in Treiman & Hirsh-Pasek, 1983).

Although these factors are undoubtedly important in fostering a child's educational growth, they cannot account for all the differences in reading skills between deaf children born to deaf vs. hearing parents. An alternative hypothesis recognizes that most deaf children of deaf parents are in fact fluent users of a language (ASL) at an early age—this expertise may be useful in learning to read. For example, Mayberry (2001) studied reading in relation to signing skills in a cross-sectional study of deaf children of deaf vs. hearing parents. The children in both groups ranged in age from 7 to 15 and had the same degree of hearing loss. Most were in day schools (as opposed to residential schools) for the deaf. The language of instruction at school was MCE along with spoken English. Importantly, all the children with deaf parents received sign language input routinely, both at school and at home. By contrast, many of the children with hearing parents only received sign language input during school hours. There were no differences between the groups in nonverbal intelligence (as measured by block design or picture arrangement on the WISC-R), nor in speech production.

Mayberry gave the children stories with simple narrative structure and asked a series of comprehension questions after each story. The stories were presented in three formats: ASL to test the children's knowledge of a natural sign language; MCE to test their knowledge of English as conveyed in the manual modality; and printed English to test their knowledge of English as conveyed through print. The questions for each story were asked in the same format as the story. The child could answer the questions in any language he or she chose.

Considering first deaf children born to deaf parents, Mayberry found significant and steady increases in the number of correctly answered questions for all three types of stories—ASL, MCE, and printed English—as the children grew older. It is very clear that knowing ASL did not in any way hinder a child's ability to learn to read English.

Turning next to deaf children born to hearing parents, Mayberry found that these children gave very few correct answers to the ASL stories, which is not surprising as they had little exposure to ASL. In contrast, the deaf children of hearing parents performed as well as deaf children of deaf parents on the MCE stories. Interestingly, the deaf children of hearing parents differed from the deaf children of deaf parents most sharply on the printed English stories. At ages seven to nine, both groups of children answered fewer than half of the printed English questions correctly. By ages 13 to 15, the deaf children of deaf parents answered nearly all the questions correctly but the deaf children of hearing parents as a group still answered only half correctly. Thus, the deaf children of deaf parents progressed steadily in reading printed English, whereas the deaf children of hearing parents did not, despite the fact that both groups had made steady progress in MCE.[2] Indeed, researchers have noted that asymptotic performance on language tests is common during adolescence within the deaf student population (e.g., Osberger, 1986). Continued growth in a language-related skill such as reading appears to depend on successful and steady language acquisition throughout early childhood and elementary school. If so, the delayed and diminished exposure to language that many deaf children experience may impede their ability to learn language-related tasks, including reading, not only during childhood but also later in life (Morford & Mayberry, 2000).

In sum, knowing ASL does *not* interfere with learning to read printed English. Indeed, ASL may actually help deaf children learn to read English. The deaf children who made steady progress in both ASL and MCE also made steady progress in reading English; the children who made progress only in MCE did not. In fact, controlling for whether a child's parents were hearing or deaf, signing skills turn out to be the best predictors of reading skill (Hoffmeister, 2000; Padden & Ramsey, 2000; Strong & Prinz, 2000). Apparently, knowing a language—even a manual language with different structure from the language captured in print—is better for learning to read than not knowing any language.

WHAT TYPES OF INTERVENTIONS MAKE SENSE?

How can we use this information to improve reading skills in profoundly deaf children? The first step in turning deaf children into readers appears to be to make sure that they have a language—any language. Deaf children who are learning ASL (or any natural sign language) from their deaf parents do not need intervention at this stage of the process; they learn language naturally and at the same pace that normally hearing children acquire spoken language (Newport & Meier, 1985; Petitto, 1992). However, deaf children born to hearing parents do need interventions and on several fronts. Early detection of hearing loss, early entry into an educational system, and early and continuous contact with fluent signers together may go a long way toward ensuring that profoundly deaf children have access to and learn a language.

But knowing a language isn't enough. After all, hearing children typically know a spoken language fluently when they arrive at the reading task, yet (as the papers in this volume attest) their success in reading is not guaranteed. Children need to learn the mapping between the language they know and print. In the case of profoundly

[2] There were, however, some deaf children of hearing parents who did read as well as the deaf children of deaf parents. In each case, the child had received sustained MCE input from his or her parents and was, in fact, a fluent user of MCE. These children confirm our suspicion that robust language is the key to learning to read.

deaf children, they need to learn the mapping between the sign language they know and print. The hope is that, in the process of learning how to map print onto sign, the deaf children will also learn English.

We are, unfortunately, no further along in knowing how to teach the print-language mapping to deaf children than to hearing children. But what we do know is that the teaching process may not be the same for deaf and hearing children. We may require different techniques to teach deaf children how to map print onto sign than are typically used to teach hearing children how to map print onto speech. Sign language researchers are beginning to turn their attention to this problem, and are looking for teaching techniques in the classrooms where many deaf readers are taught.

For example, Padden and Ramsey (2000) have identified a teaching technique that they call "chaining." Chaining encourages children to see the relation between print and the various sign systems the children know. The teacher finger spells a word, say "volcano." In finger spelling, each letter in the word is represented by a different hand configuration. The teacher then points to the word "volcano" written on the blackboard. Finally, the teacher uses an initialized sign V̲OLCANO—the teacher traces the two sides of an imaginary volcano, starting at the base and ending at the top, with two simultaneously moving hands each in a V-handshape ("V" stands for the first letter of the word "volcano"; if the sign were produced without initialization, each hand would form a "C" rather than a "V"). The teacher is explicitly calling her students' attention to the fact that these symbols all stand for the same object.

Padden and Ramsey found that chaining is used more often in residential schools for the deaf than in day schools, and more often by deaf teachers than hearing teachers. But it needn't be. Techniques of this sort can be used in day schools and can be taught to hearing teachers, assuming future research confirms that they are effective in teaching deaf children how to map sign onto print.

WHAT DO WE LEARN ABOUT READING FROM OBSERVING DEAF CHILDREN?

In addition to leading to a better understanding of how profoundly deaf children learn to read, studies of reading in deaf children can teach us about reading in general.

First, we learn the rather obvious but often ignored fact that children cannot read without knowing a language—children who have no language upon which to map the printed code never learn to read. Moreover, and most surprisingly, knowing *any* language helps children learn to read even if it is not *the* language captured in print. Deaf children who are proficient in ASL are often better English readers than deaf children who are not, despite the fact that ASL is structured very differently from English. Indeed, many deaf readers appear to map English sentences onto a visual code based on sign language. Thus, it may not be essential for deaf readers to be able to map the English sentences they read onto a phonological code. However, good deaf readers, both those who sign and those who speak, do appear to have a grasp of the phonological code on which English print is based. Whether this knowledge made them the good readers they are, or is a result of their becoming good readers, is a central question, as yet unanswered. Whatever the importance of understanding the phonological code, it is essential for children to come to the reading situation knowing a first language.

Next, we learn the rather surprising fact that children cannot learn a first language through print. One might guess that a relatively easy way to teach profoundly deaf children English would be through the printed word—an approach that would kill two birds with one stone (the child would not only learn English, but would also learn how to read). The difficulty, however, is that the approach does not work—children do not seem to be able to learn a first language through print (although they are able to learn a second language through print—consider English speakers who develop a reading knowledge of German, or ASL signers who develop a reading knowledge of English, without ever having spoken the language). The problem is not that print is processed in the visual modality, after all, children have no trouble learning ASL as a first language and ASL is processed in the visual modality. The difficulty appears to be with the print system itself, perhaps with the fact that the printed code leaves out a great deal of information that is captured in a spoken or signed language. Or, perhaps the problem is that print is not used interactively. Whatever the reason, first language learning appears to come naturally to children when the language is spoken or signed, but not when it is printed.

Finally, children need to be taught to read. Learning to read thus differs fundamentally from learning to speak or sign a language. Children will effortlessly acquire the language of their community just by living in that community. Indeed, even if a child is not exposed to a model for a conventional language, that child can invent a simple gestural system that has many of the properties characteristic of natural languages (Goldin-Meadow & Mylander, 1984; Goldin-Meadow, 1997, In press), although these self-generated gesture systems are not sufficiently developed to serve as the foundation for reading. Language (either speaking or signing) is resilient in humans. Reading is not. Reading does not come naturally to all individuals living in a community—it must be taught. The next frontier for reading research in deaf education is to understand how instruction can best be used to turn signers into readers.

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